Some Environmental Geologic Factors as Aids to Planning in Hendricks County, Indiana

By JOHN R. HILL *and* GEORGE S. AUSTIN

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Introduction

With the expanding awareness of environmental needs during the past decade, the value of geologic information to urban and regional planning has become increasingly apparent. Earth materials in the form of rock and unconsolidated sediments provide a basis for our very existence. They yield building stone, coal, oil, gas, ground water, a wide variety of minerals, and sand and gravel, and we grow our crops in soils—all from a small portion of the earth's upper crust.

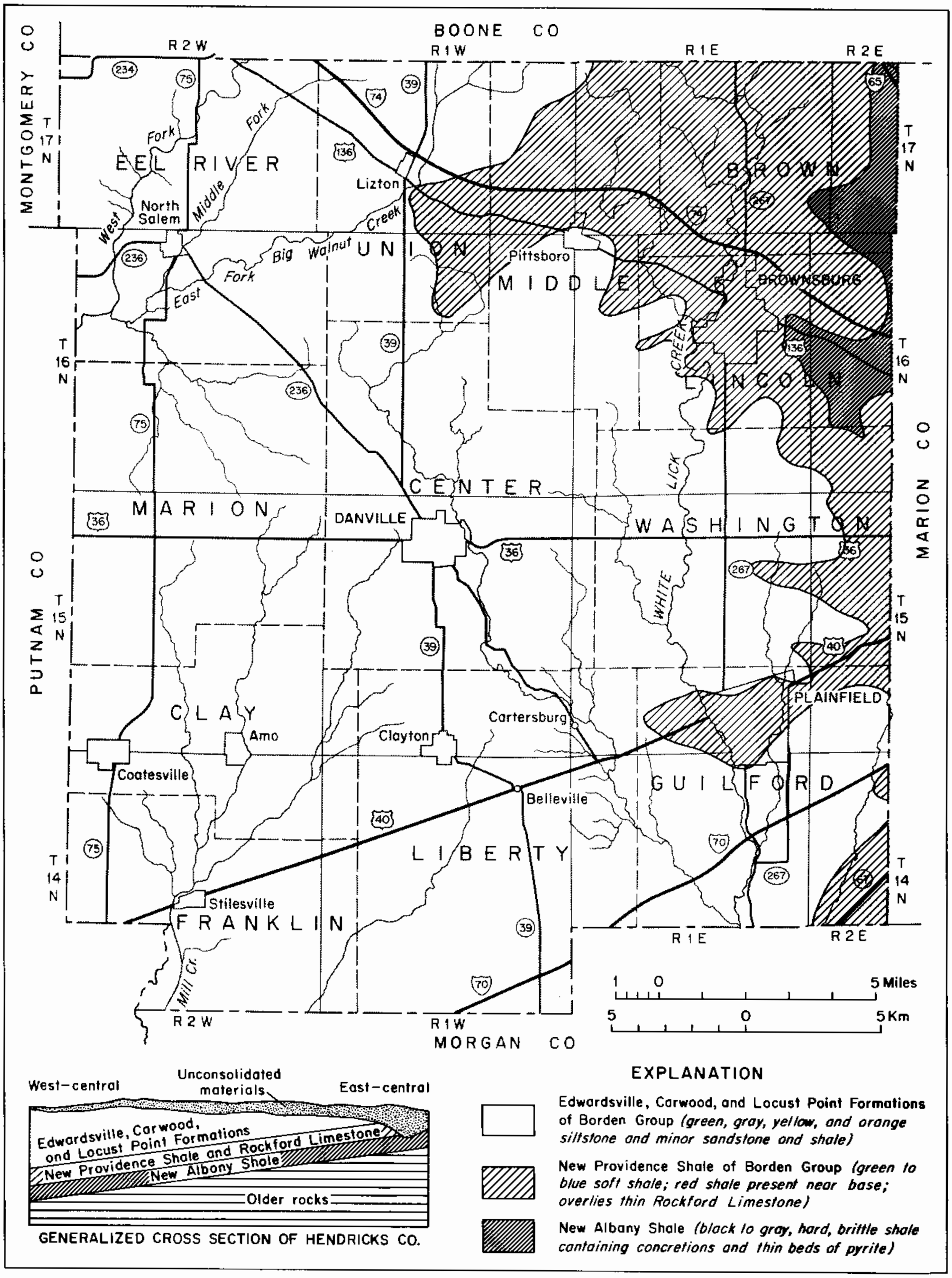
Continued use of these mostly nonrenewable natural resources and increasingly complex economic and distributional problems have ushered in the era of shortages. Clearly, every effort must be made to plan future use and urban growth in such a way as to maximize efficiency and minimize waste. This calls for a cooperative approach to planning. Practical knowledge of hydrology, geology, soils, engineering, biology, botany, and economics can help planners to make judgments that will result in the greatest benefit to urban and rural communities alike.

The maps presented here are to supply as much simple and direct geologic information for a particular area as is possible. These special geologic maps and their explanations were prepared after consultation with official representatives of Hendricks County, who outlined their then-current needs. The information contained in this report is not comprehensive, but it answers many practical questions posed at the onset of the study.

Bedrock Geology

This map illustrates the disposition of the bedrock units as they would appear today if there were no glacial deposits present to cover them up. The county is underlain by rocks of the Borden Group (siltstone, sandstone, and shale) except along the eastern third of the county where preglacial erosion stripped away the Borden rocks to expose the underlying New Providence and New Albany Shales.

The bedrock formations formed hundreds of millions of years ago when shallow seas covered much of Indiana, including what is now Hendricks County. During a long period of geologic time called the Paleozoic Era, sediments were deposited on the bottom of these inland seas and later hardened into solid rock. After deposition, a long period of erosion occurred during which upper portions of the bedrock were removed, thus exposing underlying strata. Other information on the erosional history of the bedrock surface is provided under the heading "Bedrock Topography."

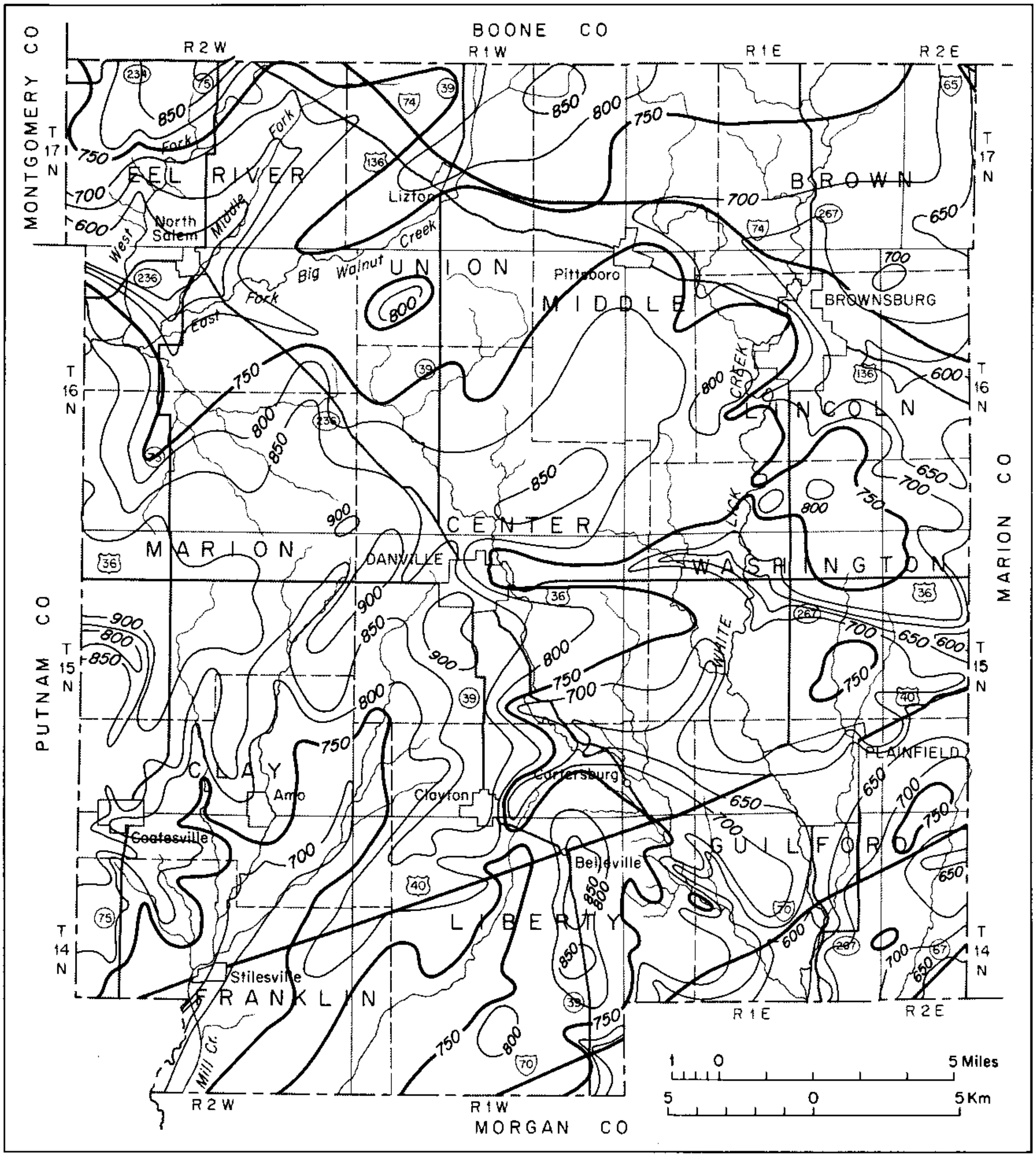


Bedrock geology

Bedrock Topography

The contour lines on this map detail the bedrock-surface topography in the same way that the surface topography is depicted on a modern topographic quadrangle map. As discussed on page 2, erosion of the bedrock surface began as soon as it was exposed to the elements. Running water cut extensive and complex valleys into the bedrock, which resulted in an elaborate system of hills and valleys that somewhat resemble the landforms in present-day Brown County.

Interestingly, some of the modern streams, such as Mill and Lick Creeks, follow nearly the same courses that their preglacial ancestors did. Bedrock topography has had a definite effect on the postglacial landscape, the first evidence of which is the similarity in drainage patterns. In some parts of the county, however, such as Washington Township, the overlying glacial drift has not only filled the old valleys but mounded high above them, thus masking the original topography completely. Glacial modification of the bedrock surface is further discussed under the heading "Drift Thickness" on page 6.



Bedrock topography. Contour interval 50 ft. Datum is mean sea level.

Drift Thickness

Prepared from water well driller's logs, this map shows the thickness of the unconsolidated deposits. Generally, the areas of greatest drift[1] thickness correspond to underlying bedrock valleys (see p. 4) but also reflect the presence of rolling ground and end moraines (constructional topographic features formed by glacial deposition). Where the glacial deposits are thinnest (for example, near Clayton and Coatesville), the underlying bedrock is generally relatively high. (Refer to bedrock topography map.)

The variable thickness of drift in Hendricks County results from both glacial erosion and deposition. Indiana was affected by at least three of the four major ice advances of the Pleistocene Epoch (last 1.5 million years of geologic time, known also as the Ice Age). Evidence for all but the last glaciation (the Wisconsinan) has either been eroded away or covered by successive deposits associated with later advances and retreats of the continental ice sheets. The most common material deposited by ice in this county is till, which is an unsorted conglomeration of sediments ranging in size from boulders several tons in weight to fine silt and clay. Such tills in part were smeared over the landscape by mile-high thicknesses of ice much as butter is spread on bread.

Periodically throughout the Wisconsinan, climatic conditions warmed and caused the ice to retreat to northern latitudes, only to readvance as temperatures fell again. During each ice-recessional phase, large volumes of water were released that cut deep valleys into the underlying till and deposited sand and gravel in these valleys just as modern rivers fill their floodways with alluvium. These deeply incised valley fills are called valley-train deposits, and, where near the surface, provide excellent sources of commercial sand and gravel.

As ice readvanced over an area, the glacial floodways and their outwash deposits were covered by a fresh layer of till. Buried valley-train deposits now carry large volumes of ground water and serve as the principal aquifers in the county. As the ice left this area for the last time some 18,000 years ago, the major drainageways now occupied by the White River, Mill Creek, and Walnut Creek were established. Once the ice had melted and the glacial uplands were drained, the meltwater sluiceways remained as broad valleys filled with sorted sand and gravel; along their margins deposits of silt and clay formed in backwater areas. Prevailing westerly winds picked up and transported silt from the sluiceway flood plains and redeposited it throughout the area and on top of the till as a fine-grained veneer called loess.

Thus, the whole of the glacial and immediately postglacial deposits found in Hendricks County consists of till, interlayered sand and gravel, recent alluvial deposits, and loess. The vertical and lateral heterogeneity of these deposits is so great that the descriptions provided here should be considered as generalities. The actual vertical sequence at any one place may differ from the condition stated above in general terms.

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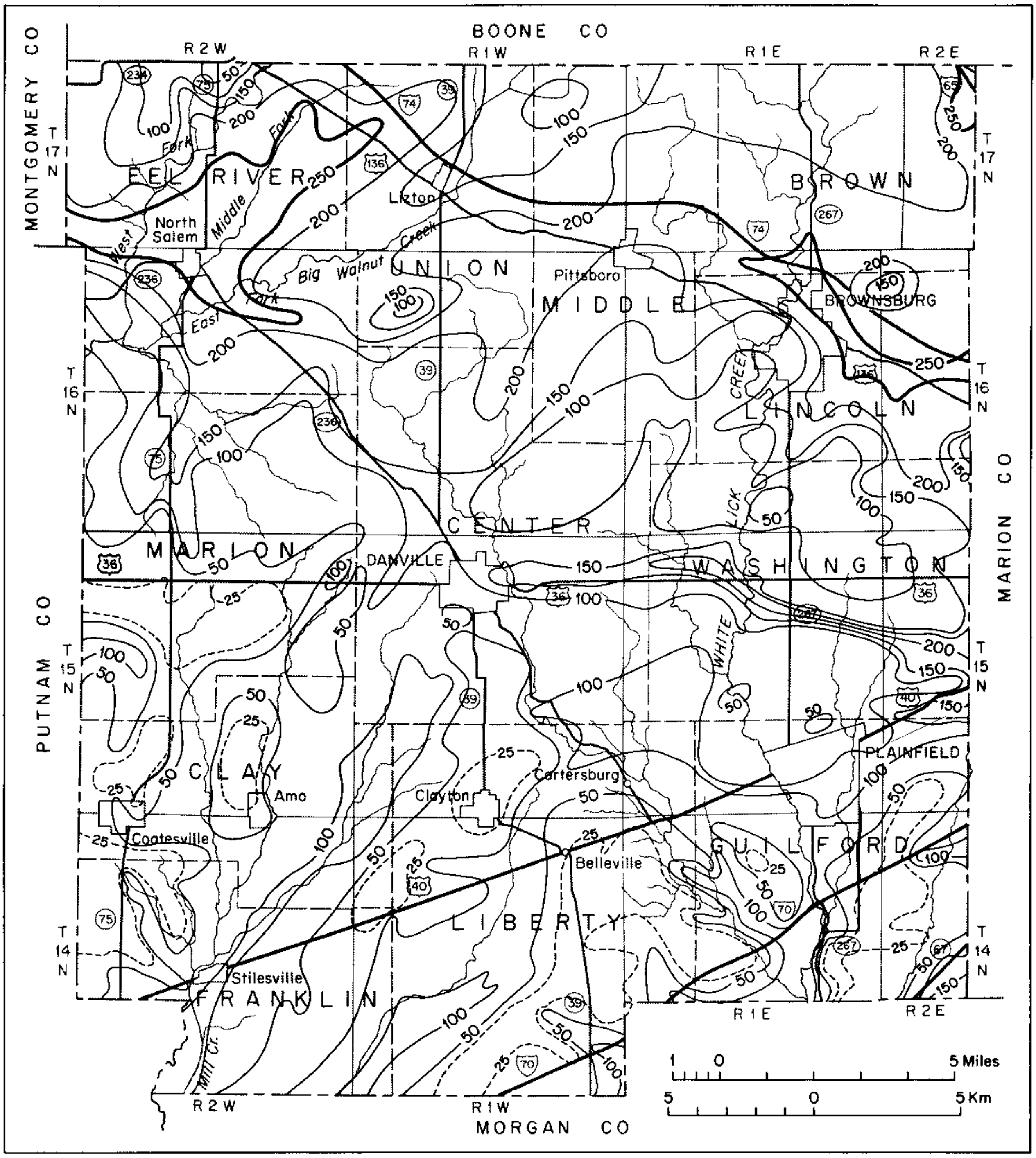
[1] Drift refers to all deposits of glacial origin, including those of glaciofluvial origin.



Drift thickness. Contour interval 50 ft. 25-ft supplementary contour shown with dashed line.

Water Well Information

Two kinds of aquifer systems are present in Hendricks County: the bedrock aquifer, which consists of porous and permeable sandstone, and glacial drift aquifers, which consist of sand and gravel units generally bounded above and below by nearly impermeable till. The bedrock aquifer (refer to drift thickness map for information on depth to bedrock) is mostly restricted to sandstone within the Borden Group, although some ground water is extracted from the thin overlying shale. For the most part, this shale has low permeability, high iron and sulfur content, and poor yields. Bedrock wells (open circles on map) having relatively high static water levels suggest high hydrostatic heads caused by the confining effect of an impermeable cover material on top of the aquifer. The bedrock wells generally are not good producers because the water-bearing units are thin and have low permeability.

Almost all wells producing 100 gallons per minute[2] or better are completed in the unconsolidated drift aquifers, the best producers being restricted to buried river valleys that are now filled with great thicknesses of highly permeable sand and gravel of valley-train origin. Walnut and White Lick Creeks course over much of the buried preglacial valley trends, so that many of the best producing wells happen to be on or near the flood plains of these creeks. Most of the drift aquifer recharge takes place along the larger streams, so the highest yields are expected along their courses. Perched water tables within the glacial till are common. Yield from perched ground-water reservoirs is low because most of the water-bearing deposits are small pods or lenses of sand and gravel within an impermeable till matrix. Depths to reliable water-bearing units within glacial deposits are less predictable than are depths to water in bedrock because of the compositional irregularity of these deposits. Glacial aquifers may thicken or thin abruptly and even pinch out altogether. In fact, lateral regularity throughout a given sand and gravel horizon is exceptional. Therefore, depths to principal glacial aquifers cannot be predicted on a county-wide basis. Wells close to a proposed drilling site, however, are excellent guides to probable drilling depths and to water yields.

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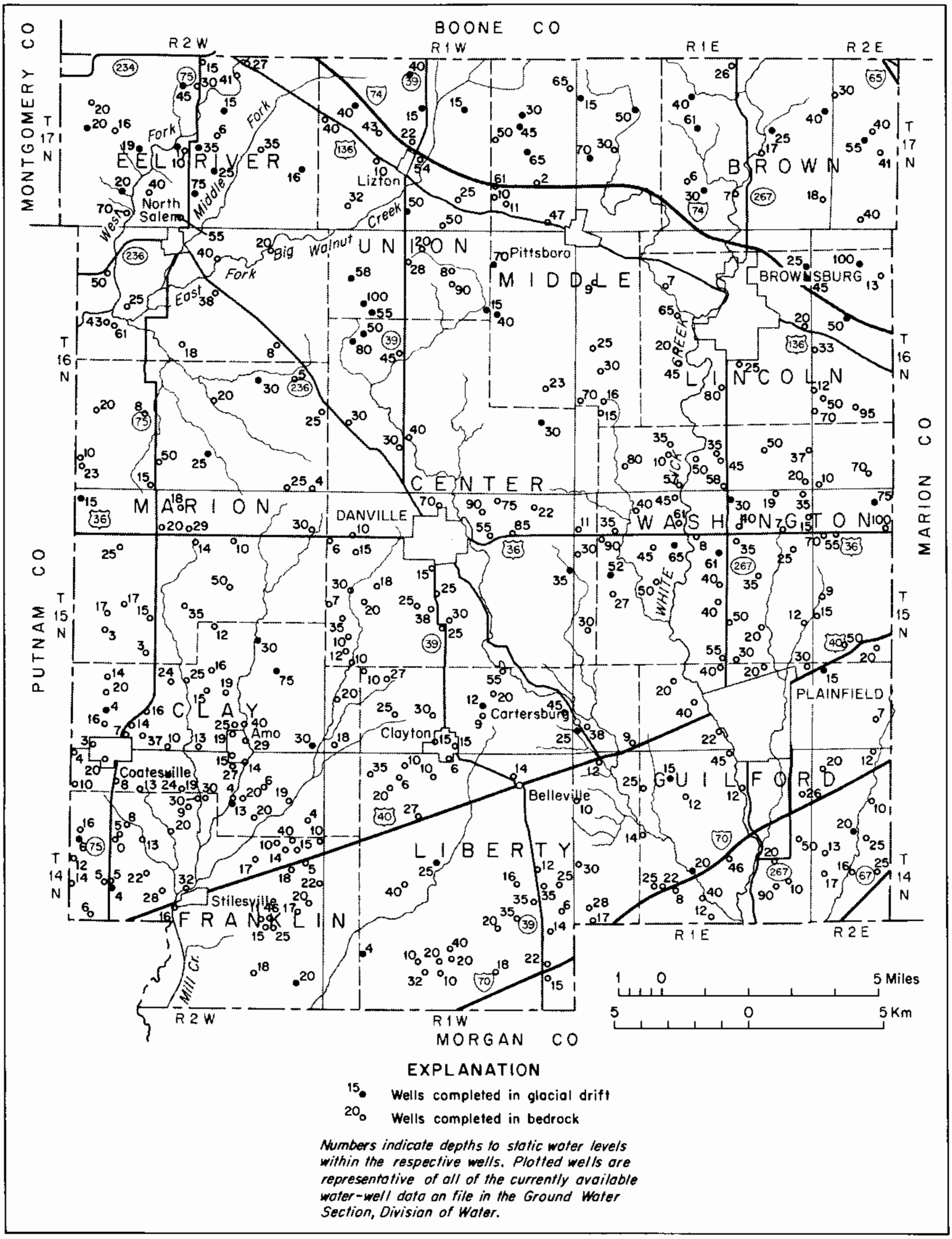
[2] All ground-water information was provided by the Division of Water, Department of Natural Resources.



EXPLANATION

15● Wells completed in glacial drift

20○ Wells completed in bedrock

Numbers indicate depths to static water levels within the respective wells. Plotted wells are representative of all of the currently available water-well data on file in the Ground Water Section, Division of Water.

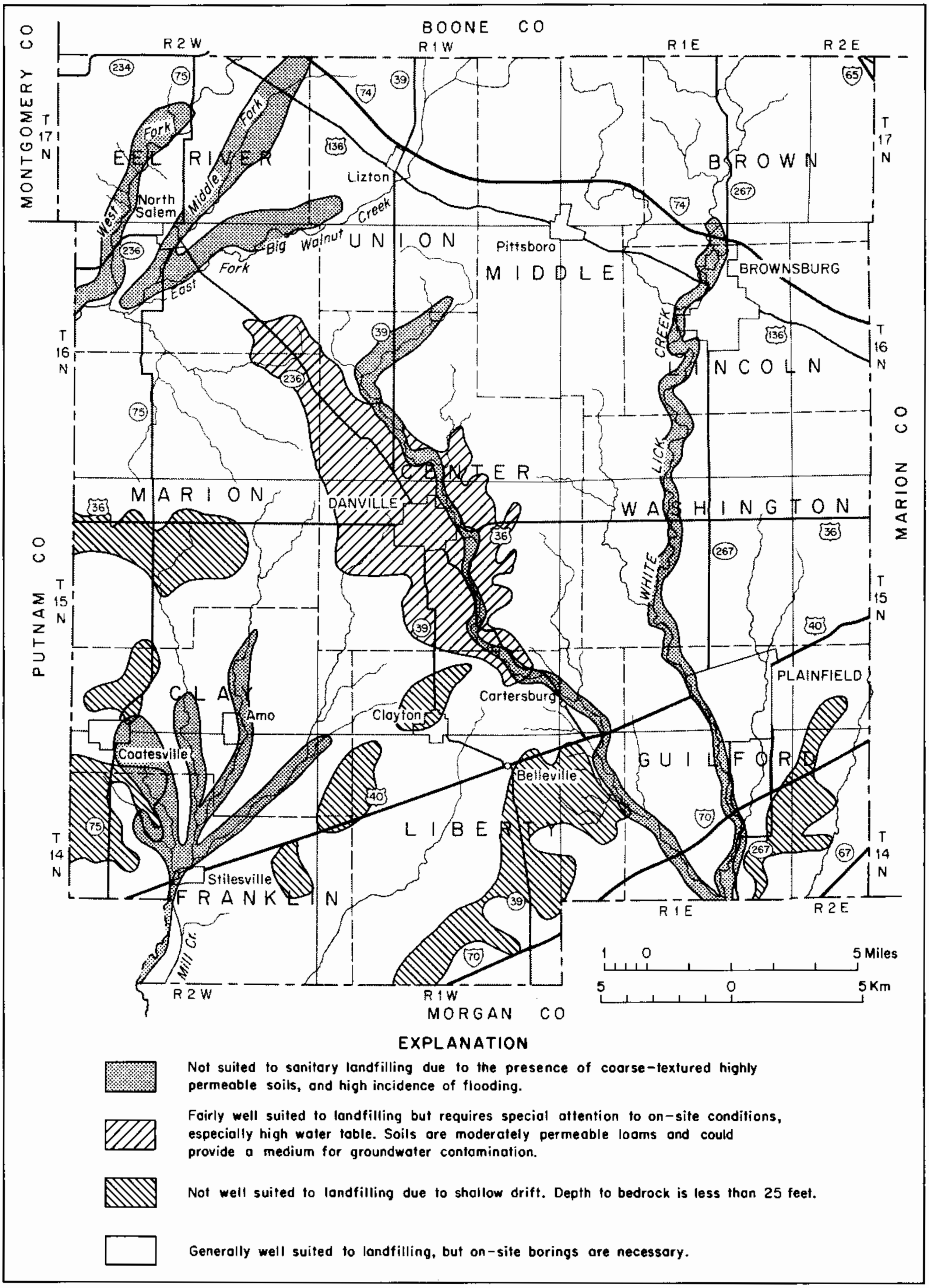
Water well locations and corresponding depths to static water levels

Sanitary Landfill Information

The most important geologic requirements for a sanitary landfill site (summarized from Indiana Geological Survey Special Report 5) are: (1) the base of a proposed landfill should be in relatively fine-grained materials and more than 20 to 30 feet above the shallowest aquifer; sites should not be located in abandoned sand and gravel pits for this reason; (2) the base of a proposed landfill should be above the highest seasonal level of the water table; (3) a proposed site should not be subject to flooding; sites should not be located on river flood plains for this reason; and (4) adequate cover material must be available near a proposed site.

In Hendricks County, much of the land is fairly well to well suited to sanitary landfilling because most of the near-surface materials consist of fine-grained, relatively impermeable till and loess. In most areas the water table is sufficiently low to permit excavation for a fill, and adequate cover material is present. Two problems may be encountered: (1) a hardpan exists in many parts of the county at an average depth of 12 feet below grade, and (2) owing to the fine texture of most of the soil materials, excavation and working of these materials can be difficult, especially in dry weather. The hardpan is generally no more than 1 or 2 feet thick but requires special equipment to break through it. Furthermore, the hardpan, which is an aquitard (nearly impermeable layer), is commonly associated with a perched water table. The hardpan is a discontinuous unit and should not, therefore, be relied on to prevent leachate contamination of the underlying aquifers.

On-site borings are essential for all proposed landfill sites, because the exact local conditions may differ from the map generalizations.



EXPLANATION

▩ Not suited to sanitary landfilling due to the presence of coarse-textured highly permeable soils, and high incidence of flooding.

▨ Fairly well suited to landfilling but requires special attention to on-site conditions, especially high water table. Soils are moderately permeable loams and could provide a medium for groundwater contamination.

▧ Not well suited to landfilling due to shallow drift. Depth to bedrock is less than 25 feet.

☐ Generally well suited to landfilling, but on-site borings are necessary.

Land-use suitability for sanitary landfilling

Septic System Information

Most of Hendricks County is poorly suited to the use of the septic system because of low-permeability soils and a seasonally high water table. The dominant earth material in the county is glacial till of loamy to silty loam texture that is covered by loessial[3] silt of variable thickness. Both till and loess have relatively low permeability, and septic effluent does not percolate readily through these materials. Septic fields usually require tiling, especially in flat or depressional areas, to provide proper drainage because of their low water-transmitting properties. Fields throughout the county require extensive tile and finger systems, and even then heavy rains can drastically reduce efficiency of a given field.

Soils that do offer fair to good septic suitability include Ockley, Fox, Martinsville, Russel, and the loamy phase of the Miami Series. All these soils, except the Miami soils, develop atop outwash sand and gravel or atop outwash loess mantles. These soils do not offer optimum conditions, however, because they are sparsely distributed and are associated with high water tables or other potential water-table contamination problems. Generally, the Miami soils offer the best suitability to septic systems.

As the county grows, the need for municipal sewer systems to replace overtaxed septic fields will become apparent.

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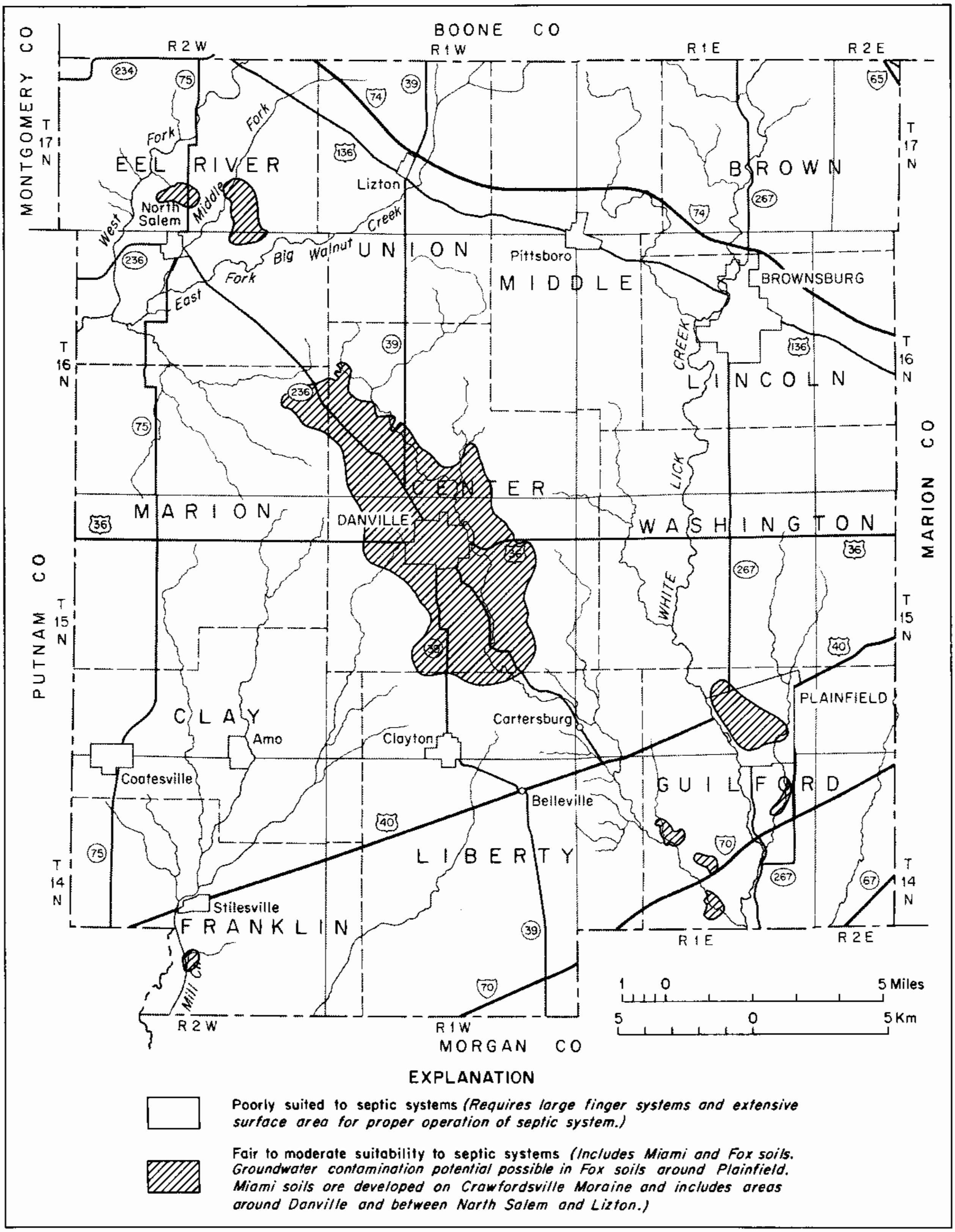
[3] Loess is a windblown deposit composed of silt-size particles.



EXPLANATION

☐ Poorly suited to septic systems *(Requires large finger systems and extensive surface area for proper operation of septic system.)*

▨ Fair to moderate suitability to septic systems *(Includes Miami and Fox soils. Groundwater contamination potential possible in Fox soils around Plainfield. Miami soils are developed on Crawfordsville Moraine and includes areas around Danville and between North Salem and Lizton.)*

Land-use suitability for septic systems

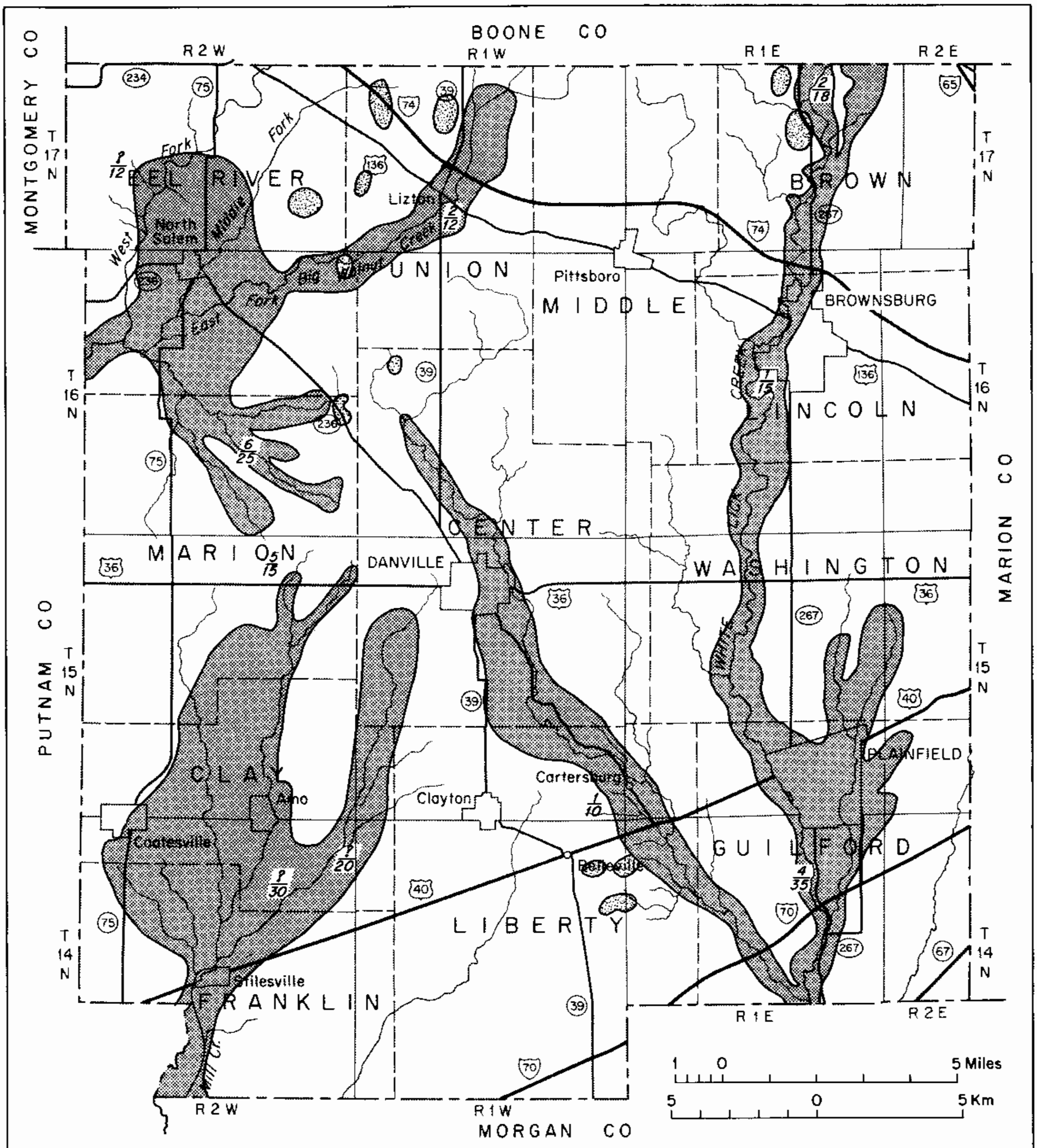
Sand and Gravel Information

Glacial valley-train deposits along the streams account for most of the sand and gravel deposits in Hendricks County. Carried hundreds of miles from their points of origin by ice and water, these materials were deposited in front of the waning Pleistocene glaciers by torrents of meltwater that washed and sorted the sand and gravel and left variable thicknesses of these sediments along the old meltwater courses. Since Pleistocene time, valley-train materials have been reworked and redeposited by the modern streams flowing over them.

Hill and moundlike structures composed of stratified sand and gravel called kames are scattered throughout the county and account for a minor amount of the potential aggregate materials. Kames are ice-contact features that formed directly adjacent to the melting glacier (as it retreated from the area). Deposits of coarse to very coarse gravel are found within or at the base of many kames.

The information on this map was compiled from water well records on file in the Ground Water Section, Division of Water, Department of Natural Resources, and from field investigations of operating and abandoned gravel pits throughout the county. The siting of kame and kame-terrace deposits was taken from geologic maps on file at the Indiana Geological Survey.

Guilford, Brown, and Liberty Townships probably contain greater quantities of sand and gravel than do the other townships. All of Guilford Township has good potential, but only the northwest portion of Brown Township and the northeast quarter of Liberty Township appear to offer good potential in those townships. Areas in which sand and (or) gravel is exposed at the surface should be considered as potential gravel extraction sites in zoning considerations. Terraces are developed along some of the creeks in the county, but in general they are not large enough to supply sizable quantities of sand and gravel. In the center of sec. 15, T. 15 N., R. 1 W., a terrace deposit as large as 3 acres is present, but it is an exceptional example. White Lick Creek and its branches are the most highly exploited areas of sand and gravel in the county, although nearly every stream bears some evidence of former removal of sand and gravel.



EXPLANATION

▨ Areas of greatest exploration potential, including most of the valley train and recent sand and gravel deposits found on the flood plains of the streams and in adjacent areas where the broader glacial flood plains formed *(In portions of the shaded area gravel deposits are overlain by 10–25 feet of till. The discontinuous nature of these buried deposits make it impossible to assure economic finds thoughout the area at depths less than 25 feet.)*

░ Kames and kame terraces *(Considered to be secondary sources of sand and gravel primarily suited to small operations. Only larger kames are shown.)*

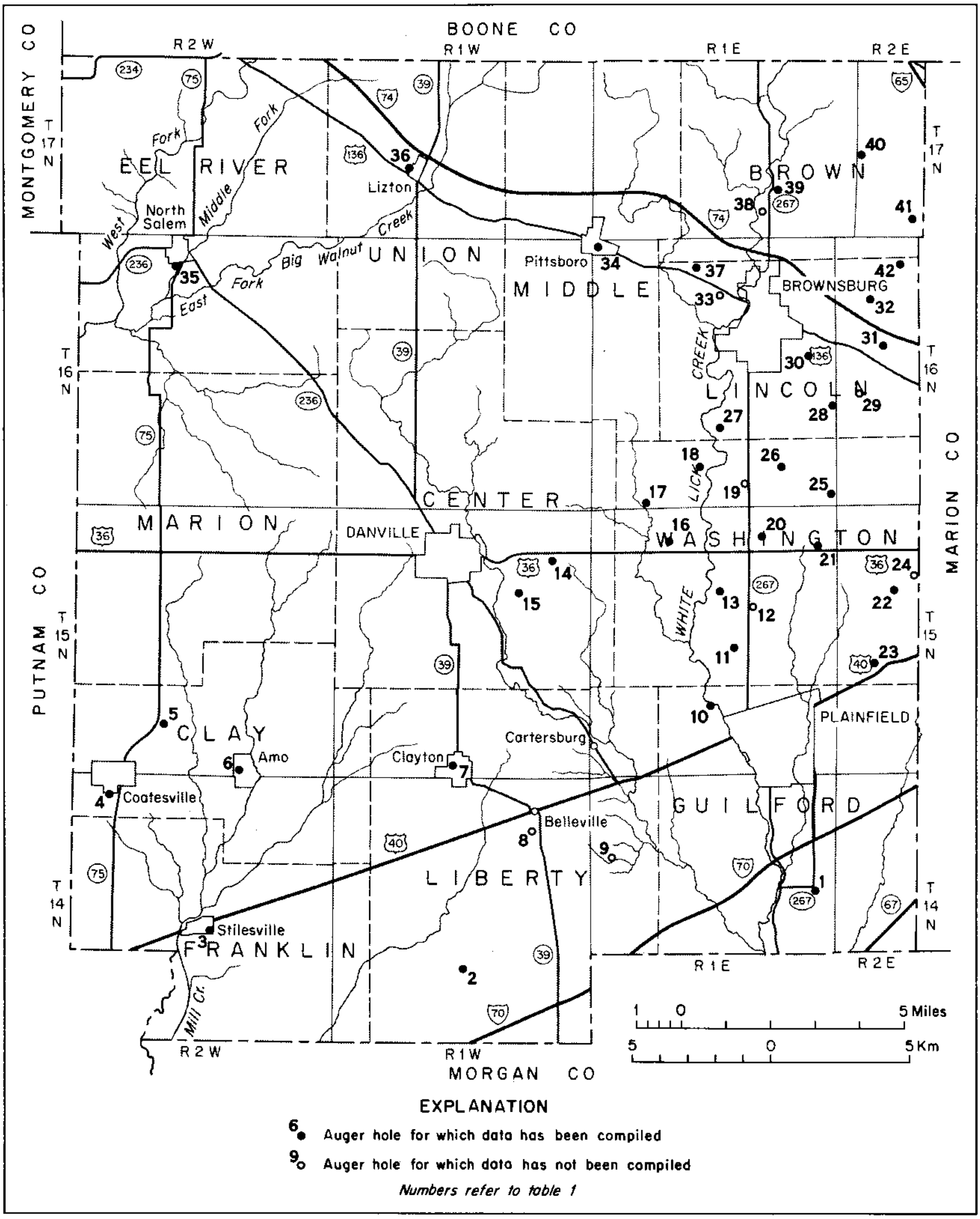
$\boxed{\frac{5}{12}}$ Thickness of overburden and sand and gravel unit *(e.g., 5/12 indicates 5 feet of overburden and 12 feet of sand and gravel.)*

Sand and gravel resources

Auger Boring Information

The numbered localities on this map are sites at which subsurface information was gathered. Table 1 provides a summary of the data gathered at each site where samples were collected. The entries labeled "Texture," "Total carbonate," and "Atterberg limits" were derived from laboratory analyses of the samples. Texture refers to the percentages (expressed as weight percent of the total sample) of the different particle sizes constituting the total sample (granule, 4 to 2 mm; sand, 2 to .063 mm; silt, .063 to .004 mm; and clay, .004 to .00006 mm). Total carbonate is the percentage by weight of calcium carbonate and calcium-magnesium carbonate of the sample that passed through a 200-mesh sieve. If the total carbonate content is more than 3 to 5 percent, the sample is considered to be unweathered. That is, the interval from which the sample was taken has not been exposed to subaerial oxidation and leaching as have modern soils. Atterberg limits (liquid and plastic limits) are the values (expressed as percent by weight of moisture in the sample) at which the soil behaves as a liquid or a plastic. The plasticity index is derived by subtracting the plastic limit from the liquid limit and is used in rating soil strengths and behavior under different moisture and load conditions. Wherever available, compressive strengths (given in tons per sq ft) are presented along with the stratigraphic description in table 1.

Locations for the boring sites were predetermined by officials of the Hendricks County Planning Commission to answer specific questions about stratigraphic, hydrologic, and engineering conditions within and near various towns and subdivisions. The information was not gathered to make general engineering or geologic interpretations but rather to illustrate some of the properties of the subsurface materials at particular points of interest to the county planners.



Locations of auger boring sites

Table 1. Geologic and engineering data for 42 sites on the map of Hendricks County showing locations of auger holes (p. 17)

Location No.	Depth (ft)	Stratigraphic description	Texture[1]				Total carbonate[2]	Atterberg limits		
			Granule	Sand	Silt	Clay		Liquid limit	Plastic limit	Plasticity index
1	0- 3	Brown silt-loam till (sand in patches), 3 tons per sq ft strength at 8-percent field moisture	0.2[3]	39.7	44.9	15.3	24.32	18	13	5
	3- 12	Yellow-brown oxidized clay-rich till	2.4	10.6	21.1	46.1	13.12	21.5	8.2	13.3
	12- 20[4]	Gray shale								
	20-100	Sandy blue soft shale								
2	0- 3	Oxidized B-horizon of loamy till								
	3- 10	As above, but unoxidized and unleached								
	10- 15	Silt-loam till, drier than above with increase in compressive strength								
	15- 20	Progressively harder blue clay and silt	0.3	8.6	65.9	25.5	2.63	22	12	10
	20-147[4]	Alternating sandstone and shale								
	147-480[4]	Shale								
	480-492[4]	Limestone								
3	0- 3	Fill								
	3- 8	Brown mottled till	0.5	6.3	56.6	37.0	24.44	24	18	6
	8- 13	As above, but saturated								
	13- 32	As above, alternately dry-wet								
	32- 38	Water sand								
	38- 45	Stiff till (>2 tons per sq ft)								
	45+[4]	Blue stone (probably shale)								
4	0- 3	Fill								
	3- 5	Brown till, .5-.75 ton per sq ft								
	5- 10	Reddish silt loam								
	10- 12	Sandy saturated layer, oxidized								
	12- 16	Stiff gray till								
	16- 17	Very stiff gray till (>3 tons per sq ft compressive strength)								
	22- 45[4]	Blue stone (shale)								
5	0- 2	Fill								
	2- 5	Sandy till								
	5- 8	Water sand	0.9	56.2	29.3	14.5	2.24	16	12	4
	8- 12	Very soft wet mud								
	12- 25	Blue-gray stiff till								
	25- 88[4]	As above								
	88- 90[4]	Sand								
	90- 95[4]	Shale								
	95-260[4]	Siltstone								
	260-275	Blue shale								

6	0- 3	Brown to buff till								
	3- 5	Brown till (1.5 tons per sq ft)								
	5- 8	Water sand	0.2	14.05	54.2	31.7	1.78	28	23	5
	8- 18	Gray till								
	18- 70[4]	As above								
	70-130[4]	Blue shale								
7	0- 3	Fill								
	3- 8	Buff silt-loam till								
	8- 10	Water sand	1.6	37.3	33.3	29.4	2.28	28.6	17.3	11.3
	10- 13	Silty till	1.7	51.9	34.5	13.6	26.64	24.2	13.1	11.1
	13- 20	Very stiff till								
	20- 50[4]	Siltstone	1.8	17.0	63.9	19.1	1.58	21.8	0	21.8
8		No hole								
9		No hole								
10	0- 3	Brown silty sand	1.3	40.8	43.2	16.0	6.45	21.4	0	21.4
	3- 6	Very hard silty till	0.7	58.8	27.2	14.0	1.11	17.4	13.6	3.8
	6- 80[4]	Gray dense till								
	80-115[4]	Blue shale								
11	0- 2	Fill								
	2- 8	Gray till	0.0	22.4	41.7	35.9	14.32	29	18	11
	8- 20	Water sand, muddy								
	20- 35	Solid till	1.7	42.5	35.1	22.4	34.30	18	11	7
	35- 47	Alternating hard and soft layers within the till								
	47- 84[4]	Gray till								
	84-120[4]	Blue sandstone								
12		No hole								
13	0- 2	Fill								
	2- 3	Dirty sand and gravel								
	3- 8	As above	0.3	47.9	33.3	18.8	27.61	16	NP[5]	16
	8- 34	Gray till, very hard at 15 ft and deeper	0.2	47.7	34.5	17.8	29.21	17	NP	17
	34- 72[4]	Blue shale								
14	0- 10	Tan sandy loam	0.1	42.4	36.4	21.2	19.09	23	14	9
	10- 18	Water sand								
	18- 50	Very stiff clay-loam till	3.8	35.9	41.0	23.2	31.11	18	12	6
15	0- 3	Red oxidized clay till	0.0	46.0	31.1	22.9	16.67	21	14	7
	3- 5	Silt-loam till								
	5- 8	Dry buff till								
	8- 15	As above								
	15- 18	Stony layer in till								
	18- 22	Silt-loam till	0.4	52.6	32.6	14.8	33.37	15	NP	15
	22- 30[4]	Brown sandstone								
	30-110[4]	Blue-gray shale								

Table 1. Geologic and engineering data for 42 sites on the map of Hendricks County showing locations of auger holes (p. 17)—Continued

Location No.	Depth (ft)	Stratigraphic description	Texture[1]				Total carbonate[2]	Atterberg limits		
			Granule	Sand	Silt	Clay		Liquid limit	Plastic limit	Plasticity index
16	0- 3	Fill								
	3- 5	Soft wet sandy loam	0.2	42.5	38.5	19.0	32.52	17.5	NP	17.5
	5- 12	As above								
	12- 13	Gravel, saturated								
	13- 14	Muddy sand								
	14- 15	Loamy till	0.2	39.7	44.9	15.3	24.33	18	13	5
	15- 16	Gravel lens								
	16- 20	Very hard till								
	20- 30[4]	As above								
	30- 45[4]	Sand and gravel								
	45-110[4]	Gray till								
	110-112[4]	Sand								
	112-145[4]	Till								
	145-147[4]	Sand								
	147-177[4]	Gray till								
	177+[4]	Sandstone								
17	0- 3	Weathered till								
	3- 8	Light-brown wet silt loam	0.2	42.5	38.5	19.0	32.52	17.5	NP	17.5
	8+	Hard till								
	8- 58[4]	Gray till								
	58- 87[4]	Blue shale								
18	0- 3	Brown weathered till								
	3- 6	Very hard till	1.8	56.0	42.4	1.6	10.98	19.5	NP	19.5
	6- 58[4]	Gray till								
	58- 87[4]	Blue shale								
19		No hole								
20	0- 3	Sand	7.6	66.9	21.7	11.3	25.51	16.3	NP	16.3
	3- 5	Sand grading into silty clay-loam till								
	5- 8	Silt-loam till								
	8- 12	Dirty sand (stone layer at 12 ft)								
	12- 15	Resistant till								
	15- 23[4]	Gray till								
	23- 26[4]	Sand								
	26-117[4]	Gray clay								
	117-132[4]	Sand								
21	0- 3	Till	0.2	8.2	45.7	46.1	.94	27.3	24.4	2.9
	3- 6	Yellow clay zone (illuviated)								
	6- 12	As above, but sand lens at 10 ft	0.4	15.1	55.4	29.5	9.30	24.2	12	12.2
	12- 25	Very soft till								
	25- 35	Alternating soft and hard till								
	35+	Too hard to drill								

22	0- 3	Brown oxidized till								
	3- 10	Gray hard till	3.0	34.0	37.3	28.7	19.41	19.0	14.7	4.3
	10- 80[4]	As above								
	80-100[4]	Limestone								
23	0- 3	Upper soil in till								
	3- 8	Brown silt-loam till								
	8- 35	As above, very stiff; some sand lenses	2.3	34.0	46.1	20.0	21.77	17.5	13.5	4
	35-109[4]	As above, shale at 109 ft								
24		No hole								
25	0- 3	Tan-buff sandy loam								
	3- 5	As above								
	5- 10	Very hard till	5.5	49.8	29.8	20.4	27.5	15.2	12.6	2.6
	10- 30[4]	As above								
	30- 52[4]	Red sand								
	52- 80[4]	Oxidized till								
	80-135[4]	Blue shale								
26	0- 75	Gray till								
	75-110[4]	Blue shale								
27	0- 3	Till								
	3- 5	As above, 1-ft gravel layer at 5 ft								
	5- 18	Very hard blue till	2.6	32.2	47.2	20.5	37.49	15.5	13.7	1.8
	18- 44[4]	As above								
	44- 47[4]	Dry sand								
	47- 70[4]	Till								
	70-103[4]	Shale								
28	0- 3	Oxidized brown clay-silt till								
	3- 5	As above but saturated								
	5- 10	Water sand	3.0	42.6	34.2	23.2	33.06	15.9	13.4	2.5
	10- 15	Hard blue till								
	15- 76[4]	Blue till	3.3	45.5	31.3	23.4	34.88	17	11	6
	76- 81[4]	Sand								
	81-117[4]	Blue till								
	117-128[4]	Blue sand								
	128-160[4]	Gray clay till								
	160-173[4]	Sand and gravel								
29		No hole								
30	0- 3	Brown till	0.3	17.6	49.5	32.9	1.55	24	18	6
	3- 5	Sandy loam								
	5- 11	Wet sandy loam								
	11- 12	Hard stony till								
	12- 25	Till with saturated sand lenses								
	25- 28	As above, very hard								
	28- 52[4]	Gray hard till								
	52- 54[4]	Sand and gravel								

Table 1. Geologic and engineering data for 42 sites on the map of Hendricks County showing locations of auger holes (p. 17)—Continued

Location No.	Depth (ft)	Stratigraphic description	Texture[1]				Total carbonate[2]	Atterberg limits		
			Granule	Sand	Silt	Clay		Liquid limit	Plastic limit	Plasticity index
31	0- 8	Sand clay								
	8- 15	Alternating hard till and soft sandy lenses								
	15- 17	Water sand								
	17- 20	Very hard till	12.6	47.7	37.0	15.3	16.05	21.6	13.7	7.9
	20-106[4]	Till								
	106-110[4]	Fine sand								
	110-133[4]	Till								
	133-144[4]	Fine sand								
	144-150[4]	Clay till								
	150-161[4]	Fine sand								
	161-166[4]	Till								
	166-170	Sand								
32	0- 5	Brown silt-loam till								
	5- 9	As above, soft								
	9- 10	As above, very hard	1.7	28.8	47.4	23.8	25.58	19.5	14	5.5
	10- 60[4]	Till								
	60- 62[4]	Sand								
	62-166[4]	Till								
	166-169[4]	Sand								
	169-220[4]	Clay								
	220-227[4]	Sand								
33		No hole								
34	0- 3	Sandy loam								
	3- 8	Brown sandy loam till								
	8- 10	Gray sandy silt-loam till								
	10- 13	As above								
	13- 20	Till with boulders and sand blebs								
35	0- 3	Gravelly till	3.0	45.1	37.0	17.9	16.15	20.7	5.2	25.9
	3- 18	Till with sand blebs and many shale fragments	6.5	31.8	48.1	20.1	11.55	17.5	10.3	7.2
36	0- 3	Brown silt loam								
	3- 8	Tan pebbly till								
	8- 20	Very stiff gray till, hardpan at 20 ft								
	20- 30[4]	Till as above								
	30- 32[4]	Sand								
	32-206[4]	Till								
	206-212[4]	Sand								

37	0- 3	Brown sandy till								
	3- 5	As above								
	5- 8	Water sand	2.8	45.7	35.6	18.7	17.61	15.9	13	2.9
	8- 10	Clay loam								
	10- 52[4]	Clay-loam till								
	52-204[4]	Till with scattered sand lenses								
38		No hole								
39	0- 15	Brown silt-loam till, hardpan at 15 ft	4.2	43.0	44.4	12.6	27.26	15.8	13.8	2
	15-206[4]	Till								
40	0- 18	Brown and blue silt-loam till,	4.7	45.4	26.3	28.3	25.11	15.8	14.2	1.6
		hardpan at 18 ft	4.1	39.0	36.4	24.5	20.30	14.5	11	3.5
	18- 65[4]	As above, till								
	65- 68[4]	Sand	1.6	39.9	38.0	22.1	22.0	17.5	12.7	4.8
	68-160[4]	Clay and gravel								
	160-173[4]	Fine sand								
41	0- 13	Hard till, rock at 13 ft	8.1	52.6	31.4	16.0	22.90	15.4	13	2.4
	13- 62[4]	Till								
	62- 64[4]	Gravel								
	64-180[4]	Till								
42	0- 8	Very stiff silt-loam till too hard to drill	2.6	46.8	30.3	22.9	28.16	16.4	12.6	3.8
	8- 12[4]	Till, oxidized								
	12- 18[4]	Blue-mud till								
	18- 28[4]	Hardpan								
	28- 33[4]	Water gravel								

[1] Textural elements are expressed as a percentage of the total sample weight.

[2] Total carbonate is expressed as a percentage of the weight of all the sample that passes through the .074-mm sieve.

[3] Values for texture, carbonate content, etc., correspond to the depth increment adjacent to the line containing this information.

[4] This is a driller's log, not an Indiana Geological Survey boring log.

[5] NP – nonplastic.

Suggested Sources for Further Information

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